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WORKING GROUP No. 5

**APPROPRIATE TECHNOLOGY
FOR THE PRODUCTION OF CEMENT
AND BUILDING MATERIALS**

.....

**CHOICE OF APPROPRIATE CONSTRUCTION TECHNOLOGY IN THE
BUILDING INDUSTRY IN IRAN**

Background Paper

CHOICE OF APPROPRIATE CONSTRUCTION TECHNOLOGY
IN THE BUILDING INDUSTRY IN IRAN

by

F. Neghabat
UNIDO consultant

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ABSTRACT

An attempt has been made to present the status of construction industry in Iran. Statistics are given reflecting urban housing types, numbers existing and planned, the status of building materials and the extend of industrialization. The short, medium and long-term objectives for industrialization of building industry is presented. Comparisons have been made between the two categories of indigenou and imported Western technologies. Factors most important in evaluating alternative construction techniques are discussed. It is shown that the choice of appropriate technology whether indigenou or imported depends on the specifics of the project and its suitability to local conditions. The economical, labor, technical, and managerial factors, as well as the adaptability of the region to new technology is stressed. The appropriateness of indigenou technology to rural housing, and the applicability to specific project of total, partial or on-site prefabrication is described. Finally, the establishment of component industries as a foundation for a stable, equilibrium condition in building industry is emphasized .

I- BACKGROUND DATA, URBAN HOUSING

1. This section is intended to review current and future housing situation in Iran. The statistical data presented puts into perspective the status of construction industry as exists to day, reflecting also the projections for the future. (Ref.1,2)

2. The 1977 statistics reported by the Plan and Budget
*
Organization for urban population, number of persons per family and the number of urban families are shown in Table 1.

TABLE 1- POPULATION AND URBAN FAMILIES IN MILLIONS

	1978	1983	1988	1993
Urban Population	16.3	20.5	25.2	30.1
Persons/Family	4.83	4.63	4.43	4.23
Urban Families	3.4	4.4	5.7	7.1

*

Plan and Budget Organization is a Government agency at ministerial level in charge of planning development projects in Iran and has the responsibility for appropriation of funds.

3. Taking into consideration the total number of existing urban families and the fact that a total of 187000 dwelling units have been built prior to 1978 a density of 1.82 families per unit is achieved. The Government's objective of course, is to reduce this figure to unity over a span of 15 years, meaning one house per family. The projected growth shown in Table 1 and the remaining Tables in this section reflects this objective for the Government.

4. Table 2 shows the number of housing units, the percent increase, the average floor area in square meter, and the forecasts for the sixth, seventh, and eighth Development Plans.

TABLE 2- HOUSING DATA IN 1000

			6TH Develop.Plans	7TH Develop.Plans	8TH Develop.Plans
Year	1977	1978	1978-1983	1983-1988	1988-1993
No.of units	145	150	980	1720	2900
% Growth	11	4	12	12	11
Ave. fl. area (m ²)	140	130	110	110	110

Data for the sixth Development Plan starting from 1978 through 1983 indicates on average a requirement of approximately 200,000 units per year. This is a steady increase over the previous years taking into consideration the availability of resources and construction capabilities. Major portion of this activity is undertaken by the private sector, while the Government's contribution is estimated at 15%. However, 40%

of the activities of the private sector receive some form of Government support ranging from tax benefits, land provisions long term - low interest loans, and other forms of incentives.

5. Further details as to the distribution of the housing forecasts for the 6th Development Plans as regards the various income groups and the required investment is reflected in Table 3.

TABLE 3. DISTRIBUTION ACCORDING TO INCOME GROUPS AND TOTAL INVESTMENT NEEDED FOR 6TH DEVELOP. PLAN.

	Monthly Salaries	No. of units 6TH.D.P. (in Thousands)	Ave.No. Per yeat (in Thousands)	Ave.fl. area (m ²)	Investment Billion \$
Group 1	<290	334	66	75	5.68
Group 2	290-600	254	54	95	6.84
Group 3	600-1000	196	40	125	8.33
Group 4	>1000	196	40	170	10.38
Total		980	200		31.23

6. The review of housing statistics is incomplete without adequate presentation of the status of building materials in terms of available and planned production in order to meet the demand. Table 4 is intended to show the building materials supply and demand based on the foreseen development projects already referred to.

TABLE 4. BUILDING MATERIALS SUPPLY & DEMAND FOR HOUSING PROJECTS

Building Materials		1977	1978	1979	1980	1981	1982	Remarks
CEMENT in Mil. Tons	Produced	7	11	15.5	19	20	21	1976 imports = 1.2
	Required for Housing	2.9	2.7	2.8	3	3.2	3.7	
BRICKS in Billions	Produced	14.8	16.3	18	20	22	24.5	Cement Blocks & sand-lime bricks to fill the gap
	Required for Housing	6.7	6.3	6.3	6.3	6.5	7.6	
STEEL PROFILES in Mil. Tons	Produced	2.4	2.8	3.2	5.2	5.4	5.5	1976 Imports = 0.6
	Required for Housing	1.02	1.01	1.02	1.11	1.21	1.4	
GYPSUM in Mil Tons	Produced	4.2	4.8	6	6.8	7.2	7.2	
	Required for Housing	2.23	2.14	2.15	2.25	2.37	2.75	
TILES in Millions	Produced	587	1200	1670	1670	1670	1670	Surplus to be exported
	Required for Housing	289.3	376.7	378.7	409.3	433	502.3	
GLASS in Mil.m ²	Produced	6	6	10	13	13	13	Shortage
	Required for Housing	3.92	3.96	4	4.29	4.29	5.55	
ALUMINUM PROFILES 1000 Tons	Produced	26	32	40	44	44	44	
	Required for Housing	12.23	11.79	11.84	13.11	13.75	15.95	

II- INDUSTRIALIZED TECHNICAL-URBAN HOUSING (2)

7. Although traditional method of construction has its place and will remain as a major contributor to the current and future building activities, nevertheless the introduction of Western technology, creation and industrialization of housing industry was felt to be inevitable in order to meet satisfactorily the requirements of the country's Development Plans. This is essential in order to increase productivity, speed of construction, reduce waste and save in labor.

8. Table 5 shows a comparison among various building methods as regards the labor requirements to build one square meter of floor area.

TABLE 5- BUILDING METHODS- LABOR REQUIREMENTS

Time required in hours for one m ² of floor area			
	Skilled labor	unskilled labor	Total
Traditional	14	17	31
Semi-Mechanized	12	12	24
Industrialized on-site	8	6	14
Light to med. Prefab.	8	6	14
Heavy Prefab.	4	8	12

The advantage of industrialized method is clearly shown and a reduction in time of one half is obtainable as compared with the traditional methods.

9. Table 6 reflects the status and the extend of prefabrication as existed in 1976 for the three groups of building types shown.

TABLE 6- BUILDING METHODS IN 1976

Group	Bldg. Type	Total bldgs. %	Prefab. %	Bldg. method
1	One & two story load bearing brick walls	40	2.6	Light to medium prefab. for ceilings
2	Two stories and above STEEL FRAME	45	3	Prefab. Panels for Ceiling
3	Reinf. Conc.	15	3.4	-Heavy Prefab. -On site plants
	Total	100	9	

It is anticipated that the percentages shown in Table 6 for the three building groups as well as the 9% overall prefabrication will change to 15, 55, and 30 percent of the total urban construction by the middle of the sixth Development Plan implying a range of 18 to 20% industrialization. This is to be achieved through gradual introduction of industrialization in housing industry including: establishment of heavy prefabricated factories, mechanization on site or portable plants, all producing complete housing or components such as doors, windows, baths, etc., as the merit of individual

project justifies. Matters of utmost importance in this process are safety, management, financial and maintenance considerations.

10. The number of factories producing light to heavy pre-fabricated building components that are now in operation or under construction with the related capacities are presented in Table 7.

TABLE 7 DATA ON PREFABRICATED PLANTS

Plant type	NO.OF PLANTS IN OPERATION	ANNUAL CAP. IN M ² OF FL. AREA	NO OF PLANTS UNDER CON- STRUCTION	ANNUAL CAP. IN M ² OF FL. AREA
HEAVY PREFAB.	15	812000	11	3465000
LIGHT PREFAB.	33	900000	10	250000
TOTAL	48	1712000	21	3715000

11. Industrialization in housing schemes can best be achieved

through:

- Employing traditional building techniques to the best advantage,
- Introduction of new, more economical and speedier techniques,
- Prefabrication of components and/or systems,
- Productivity, better tools and machines aimed at improving rate of construction, optimization of output of man and machine.

Having these points in mind the following short, medium and long term objectives are set by the Government.

A- LONG TERM OBJECTIVES-

12.The long term objectives for urban housing industrialization

may be briefly outlined as follows:

- Establishment of SUPPORT OR COMPONENT INDUSTRY, which is product oriented rather than system oriented and is also adaptable to local conditions. This is essential for a strong, dependable basis for the building industry capable of meeting long term requirements, and allowing varieties in production.
- Application of MODULAR COORDINATION, in order to achieve standardization, minimize wastage, and obtain better coordination among building products obtained from different plants.
- Exercising QUALITY CONTROL, SUPERVISION, and compliance with LOCAL AND NATIONAL CODES, that are to be established. These are essential for successful implementation of projects.
- Improving existing and traditional BUILDING MATERIAL and allowing innovations to produce new materials utilizing indigenous resources. Any such improvement can substantially reduce overall construction cost, since 70% of total building cost is related to materials.

B. SHORT AND MEDIUM TERM OBJECTIVES

13. The actions related to short and medium term objectives towards industrialization of urban housing include:

- Introduction of CONSTRUCTION MANAGEMENT techniques for building industry, through creation of local or foreign LARGE SCALE DEVELOPERS capable of producing most economical housing in the shortest time. This helps creation of component industry and transfer of know-how.
- Establishment of HEAVY PREFABRICATION, PLANTS on a limited

basis in order to meet specific large housing requirements of a given region, while giving due consideration to the social-economical, cultural, and physical characteristics of the region.

- Establishment of ON-SITE PORTABLE PLANTS based on the technical and economical feasibility studies of specific projects.
- Use of LIGHT WEIGHT PREFABRICATED SYSTEMS as an interim solution.
- Encouragement of PRIVATE SECTOR for greater participation in establishment of plants aimed at low to medium cost housing. Incentives provided by the Government include, attractive long term, low interest loans through specialized banks, land provisions, tax benefits, issuing of appropriate permits, and guarantees to absorb part of the finished products.
- Encourage BUILDING RESEARCH activities and creation of BUILDING INFORMATION AND DOCUMENTATION CENTERS. This is essential for effective and efficient decision making in the management of technology.
- Manpower TRAINING for skilled labor, and other specialities to be inseparable part of all agreements.
- Providing better COORDINATION among all individuals and organizations involved in the construction activities.

C. FINANCING POLICIES

14. Implementation and meeting the above objectives depend largely on strong financing arrangements. The following steps are taken:

-For developers of low-cost-housing, up to 70% financing can be obtained from Government's specialized banks. The loan has low interest rate with a duration equal to the construction period. This short term loan can be converted to a long-term purchaser loan through the arrangement shown in table 8.

TABLE 8: GOVERNMENT LOANS & INTEREST RATES

Amount of Loan in \$	Interest rate in %	
	CITIES	TEHRAN
Up to 20000	3	4
20000-35000	5	6
35000-60000	8	9
Greater than 60000	regular rates	regular rates

-The loan period is 25 years for groups 1 and 2. The monthly installment not to exceed 25% of the income for group 1, and 35% for other groups.

- The lower interest rates for the housing projects in the cities, is in line with the decentralization policy of the Government. Furthermore, each city has its own quotas as related to the maximum number of housing units permitted which in turn has been decided on the basis of the materials, manpower availability and construction capability of the city.

III. INDIGENOUS TECHNOLOGY, RURAL HOUSING (3)

15. The building and construction activities in rural regions have been lagging behind the urban areas where there has been concentration of extensive large-scale development projects. The uneven development has resulted in large proportions of the rural population to migrate to the cities in search of jobs. This massive labor force have been absorbed unproductively in the urban areas creating social and artificial housing problem in certain cities. A decentralization policy was therefore employed with the objective of generating activities in the rural areas. For this purpose, emphasis is given to small-scale, labor intensive industries and services that develop local available resources and meet local needs. Low cost housing projects are integrated with self help concept, site and service approach, and improvement schemes, so that investment in housing is made available to more people.

16. Introducing sophisticated technology in rural areas has its drawbacks. It would require efficient management and administration know how such as personnel system, budgeting reforms, communication networks, tax collection, record keeping supervision, training, handling of financial transactions. The labor force lack any such industrial tradition, they have little experience with machinery and thus have scant perception of the disciplines required or of the risks incurred when dealing with various equipment, but they also often have a concept of time different than the tempo of modern industry.

17. The policy therefore, for rural housing is to use traditional construction techniques that are labor-intensive

and indigenous to local conditions. The indigenous building systems remain relevant to local needs and are based on labor use of energy and resources, and work in harmony with the natural environment. They relate to the users needs and finances, and are under the users control. Its common manifestation is low-rise small-scale informally organized shelter. A certain amount of modernization as well as mechanization is of course inevitable for reasons of higher productivity and better utilization of indigenous resources. Capital invested in indigenous industry would have a maximum regenerating effect, directly increasing employment and assist in better distribution of income thus raising living standards and developing local skills and resources. It also has the additional features of social recognition and personal satisfaction.

IV- CONCLUSIONS

18. In each category of housing technology, whether indigenous or imported, one has to identify the alternative construction techniques and to examine their suitability to local conditions. This evaluation should include not only the technological capabilities, but also the managerial and labor capabilities required for each technology. A brief comparison in terms of advantages and disadvantages of indigenous versus heavy prefabrication is given in Table 9.

19. In choosing appropriate construction technology, the aim should be "TO REACH AN STABLE AND EQUILIBRIUM CONDITION IN BUILDING INDUSTRY". Significant factors to be considered are: economical, technical, and labor matters. Economical matters include: increased productivity and efficiency, reduction in prices through increased competition, quicker return of the investment, and prevention of wastes in materials and manpower. Technical matters are: increased rate of construction, better control on quality and inspection during production and construction, and modular coordination. Finally, labor matters include training to increase skill and better job opportunity. Other matters of equal importance are adaptability of the system to local conditions and the adaptability of the region to the new technology.

20. On further expansion of the economic factors, it should be emphasized that in evaluating alternative construction techniques, the distortions in prices (the price of capital, and the wages of labor) should be noted. Failure to consider that may result in selection of more capital-intensive techniques than is economically justifiable.

TABLE 9 - HOUSING TECHNOLOGY COMPARISON

HOUSING TECHNOLOGY		
	INDIGENOUS	HEAVY PREFABRICATION
ADVANTAGES	<ul style="list-style-type: none"> - Uses local know-how, energy, and resources. - Lower prices - better acceptance by people. - Adaptability to local conditions. - Flexibility 	<ul style="list-style-type: none"> - Standardization and uniformity of products - Better quality control (Factory conditions). - Quick installation. - Minimizes on-site activity and wastes. - Easier design and engineering calculations. - Mass production
DISADVANTAGES	<ul style="list-style-type: none"> - Can not be used for large-scale projects in short time - Lacks uniformity in materials and finished products. - Labor intensive. - Slower construction rate. 	<ul style="list-style-type: none"> - Transportation difficulty. - Need for heavy machineries. - Limited flexibility. - Capital intensive - Need for training - Connection difficulties - Economical only for large projects - depends on imported technology

21. Because of the costly nature of construction facilities, financing, which is usually through domestic sources, becomes an important issue in the construction activity in need of careful consideration. The interest paid on capital may add from 5 to 10 percent to the capital cost of many building projects depending upon prevailing interest rates, financial arrangements, and fiscal conventions. The details of the financing process may vary depending upon the type, size, and location of the construction project, the participants, economic conditions, and so forth.

22. Using new technology to produce industrialized housing can be acceptable to people only if the following four objectives are achieved:

- 1- It needs to be socially and culturally valid.
- 2- It should be sufficiently economical to ensure that the greatest number of people can afford it.
- 3- It should ensure the maintenance of health of the occupants.
- 4- There should be a minimum of maintenance over the life of the building.

23. Finally, for successful implementation of industrialized technology and continued improvement of indigenous technology, adequate attention should be given to Research and Development in building and housing activities. Its correct application into practice and potential cost savings may prove to be the most valuable investment. It is through research and development activities that indigenous resources may be employed properly, innovative building materials and techniques may be developed, and increased productivity achieved, while giving due considerations to economics.

V. SUMMARY

24. Housing as an industry in Iran is a relatively new enterprise. In this paper attempt has been made to present the status of construction industry in Iran as it exists to day. For this purpose certain statistics have been given reflecting urban housing types, numbers existing and planned, the status of building materials and the extent of industrialization. The short, medium and long-term objectives for industrialization of building industry are dealt with. In conclusion, Comparisons have been made between the two categories of indigenous and imported technologies. Factors most important in evaluating alternative construction techniques are discussed.

25. As regards the choice of appropriate construction technology, there is no one cure-all solution. Factors such as size, type, location, of specific project, future housing and building activities in the area, availability of resources including materials, energy, and manpower, environmental conditions, social, cultural and many other considerations play a significant part in the selection of the appropriate technology.

26. In general the indigenous technology is best suitable for rural housing in Iran. As the cost of imported goods are rapidly rising, indigenous systems representing hundreds of years of accumulated experience on how to employ what is locally available can best be used to meet local needs economically. It also can, with some degree of mechanization and modernization, produce satisfactory results in Urban housing. Understanding and expanding the potentials of indigenous systems to meet contemporary needs would enable development to be more appropriate and acceptable to the

majority of people.

27. The industrialized technology, on the other hand, is capital intensive and its introduction, with due consideration to local conditions, is essential for accelerated development of the region and for establishment of a modern industrial sector. Whatever the choice may be, self reliance and self sufficiency should be the goal.

28. Large panel prefabrication is best suitable for large scale projects in order to justify the initial capital investment. Large scale housing projects are built in the belief that repetition of units, bulk buying of materials, etc., save on costs. However, administration and organization costs during construction, and management and maintenance costs after construction can be substantial if adequate care is not taken. For smaller projects, onsite prefabrication may prove more economical as the system is neither totally labor nor capital intensive, but a combination of the two.

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